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TANK FOR COMBUSTIBLE FLUIDS, IN PARTICULAR LIQUID FUEL
[TANK FÜR BRENNBARE FLUIDE, INSBESONDERE FLÜSSIGKRAFTSTOFF]

GUNTHER ENDERS, et al.

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INVENTOR	(72):	Gunther Enders, Georg Lindner, and Herbert Schrami
APPLICANT	(71):	Messerschmidt-Bölkow-Blohm GmbH
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Patent Claims

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1. A tank for combustible fluids, in particular liquid fuel, the container wall of which consisting of metal or plastic is laminated on at least one part of its outside with one or more layers of woven laminate fabric, wherein the layers of laminate fabric consist of polyaramide fabric (*11d*).

2. The tank according to Claim 1, wherein the laminating binder consists of nitrile rubber or epoxy resin.

3. The tank according to Claim 1 or 2, wherein the polyaramide fabric consists of an up to 1 mm thick fabric in 4/4 twill having a surface weight of 600 to 670 p/m^2.

4. A tank according to one of Claims 1 to 3, wherein the outermost laminate fabric (*11g*) has an outer polytetrafluoroethylene coating.

5. The tank according to one of Claims 1 to 3, wherein the outermost laminate fabric layer has an outer laminating binder coating having added carbon and/or soot particles.

6. The tank for combustible fluids, in particular liquid fuel, the container wall of which consisting of metal or plastic is laminated at least on one part of its outside by means of a laminating binder having several laminate fabric layers, a laminate fabric layer deviating from the outermost laminate fabric layer being directly located between two swelling layers that can be made to swell by the fluid, wherein at least four laminate fabric layers (*11b*–g, h) are

*Numbers in the margin indicate pagination in the foreign text.

provided and the laminate fabric layer of the inner swelling layer (*11h*) following the innermost laminate fabric layer (*11b*) is located directly in front of the inner swelling layer (*11h*) and consists of a fluid barrier layer (*11i*).

7. The tank according to Claim 6 or 7, wherein the laminating binder consists of nitrile rubber.

8. The tank according to Claim 6 or 7, wherein the swelling layers (*11h*) consist of natural rubber.

9. The tank according to one of Claims 1 to 8, wherein the laminate fabric layers (*11b*-g, i) consist of polyamide fabric, tire cord fabric, or carbon and/or glass fiber mats.

10. The tank according to Claim 9, wherein the polyamide fabric is a polyaramide fabric.

11. The tank according to Claim 10, wherein the polyaramide fabric is a solid fabric, a stretch fabric, or a cord fabric made of combed individual threads.

12. The tank according to Claim 11, wherein the solid polyaramide fabric consists of an up to 1 mm thick fabric in 4/4 twill having a surface weight of 600 to 670 p/mm^2.

13. The tank according to one of Claims 6 to 12, wherein the fabric of the blocking layer (11 h) consists of an aliphatic polyamide.

14. The tank according to one of Claims 6 to 13, wherein, apart from the fluid barrier layer (*11h*), only the innermost and/or outermost laminate fabric layer consists of an aliphatic polyamide.

15. The tank according to one of Claims 6 to 14, in the design having an outermost laminate fabric consisting of a polyaramide fabric, wherein the outermost laminate fabric layer (*11g*) has an outer polytetrafluoroethylene coating.

16. The tank according to one of Claims 6 to 14, wherein the outermost laminate fabric layer has an outer laminating binder coating having a carbon and/or soot particle addition.

Description

The invention concerns a tank for combustible fluids, in particular liquid fuel, the container wall of which consisting of metal or plastic is laminated at least on one part of its outside by means of a laminating binder having one or more laminate fabric layers. In addition, the invention concerns such a tank in a design having several laminate fabric layers, a laminate fabric layer deviating from the outermost laminate fabric layers being located directly between two swelling layers than can be swollen by the fluid. – A "directly" sequential arrangement of two layers within the framework of the invention also means an adjacent arrangement of these two layers with the intercalation of a laminating binder layer.

In the case of a known tank of the named kind (DE AS 15 86 651) two self-sealing polyurethane layers are cast onto the container wall, between which the two swelling layers bear supporting fabric, for example, consisting of polyamide. The swelling layers activated by the emerging fluid in this case should close the remaining openings, that, for example, remain as a result of the exhaustion of the self-sealing action in the case of a bullet fired into the polyurethane layers. An significant disadvantage of this known tank is first to be seen in the fact that the layers applied to the container wall cause practically no increase in the container strength, as would be desirable in particular in the case of tanks for motor vehicles, for example airfield tankers; the reason for this is to be seen in the fact that the laminate fabric layers perform only a protective

function for the respective swelling layer. Furthermore it is disadvantageous that there is primary explosion protection and leak protection in the case of only relatively small caliber bullets, because in the case of greater calibers, the openings created, respectively remaining in the polyurethane and swelling layers, are too great to be closed by self-contraction or swelling before greater amounts of fluid have emerged. The invention is intended to solve these problems.

The object of the invention is to use relatively simple means to give increased strength and, in particular, improved primary explosion and leak protection in the case of a tank of the type mentioned above being shot.

According to the invention this object is achieved by having the laminate fabric layers consist of polyaramide fabric. The term /2 'polyaramide' is used for fibers of completely aromatic polyamides, that also are called aramides. Ullmanns Enzyklopädie der technischen Chemie (Ullmann's Encyclopedia of Technical Chemistry). Vol. 11, 1976, p. 342ff is to be consulted. Polyaramide means, in particular, poly-p-phenylene terephthalamide.

In this case the invention is based on the knowledge that an increase in the tank container strength, that is, improved protection against mechanical damage in general, for example in the case of transport accidents, can be achieved only via the laminate fabric layers and is optimally suited for this.

There are several possibilities for the further development of the previously presented invention. Thus it is advantageous to use nitrile rubber or (curable with a curing agent) epoxy resin as a laminating binder. In particular, a 4/4 twill fabric up to 1 mm thick, having a surface weight of 600 to 700 p/m^2, has proved to be worthwhile in practice; as a rule, already two of these fabric layers are sufficient in order to achieve more than sufficient container strength. In so far as there is also good chemical resistance with respect to externally acting acids, solvents, and the like, it is recommended that the outermost laminate fabric layer be provided and utilized with an outer polytetrafluoroethylene coating. In addition, a good anti-static effect is achieved if the outermost laminate fabric layer has an outer laminate binder coating to which carbon and/or soot particles have been added.

Another solution to the above-mentioned problem may be achieved according to the invention with the design having several laminate fabric layers and two swelling layers in that at least four laminate fabric layers are provided and the laminate fabric layer following the innermost laminate fabric layer is located immediately before the inner swelling layer, as well as consisting of a fluid barrier layer.

In this case the invention is based on the concept, recently confirmed in practice, that for a predetermined minimal increase in strength in general and protection against bullets of 30 caliber and higher, in particular, at least four laminate fabric layers, of which

the one immediately before the inner swelling layer consists of a fluid barrier layer, which limits swelling capacity over the surface.

There are also several possibilities for the further development of this solution within the framework of the invention. Thus, the laminating binder also preferably consists of nitrile rubber. It is advantageous to make the swelling layers out of natural rubber. Polyamide fabric, tire cord fabric, or carbon and/or glass fiber mats (also in the form of fabric) also are concerned, and indeed also in different combinations. Very particularly, a polyaramide fabric is particularly suited as polyamide fabric; in this case polyaramide means aromatic polyamide, in particular poly-p-phenylene terephthalamide. A polyaramide fabric of a 4/4 twill fabric up to 1 mm thick having a surface weight of 600 to 670 p/m^2 has proved to be best. However, the fabric of the fluid barrier layer can easily consist of an aliphatic polyamide. Apart from this fluid barrier layer, only the innermost and/or outermost laminate fabric layer should consist of an aliphatic polyamide. In so far as there should be good chemical resistance to externally acting acids, solvents, and the like, it is recommended that the outermost laminate fabric layer be made as a polyaramide fabric having an outer polytetrafluoroethylene coating. In addition, a good anti-static effect is obtained if the outermost laminate fabric layer has an outer laminating binder coating to which carbon and/or soot particles have been added.

The invention is explained below by means of a drawing, here:

Fig. 1 shows a schematic cross-section through a transport tank having a laminate applied in areas,

Fig. 2 shows the symbols used for indicating the individual laminate layers,

Figs. 3 to 6 show four versions of a laminate against mechanical injury and chemical effects,

Figs. 7 to 10 show four version of a laminate against mechanical injury and having additional explosion and leak protection in the case of being shot, and

Figs. 11 to 14 show four versions of a laminate against mechanical injury and chemical exposures as well as with explosion and leak protection in the case of being shot.

As is evident from Fig. 1, the outside of the container wall of a transport or storage tank for hazardous liquid or gaseous substances is entirely or partially provided with laminate layers *11a* to *11i*. The laminate layers consist of a combination of different materials, which will be explained in greater detail below. In the combinations of these layers the material-specific properties of the individual layers are now chosen so that their overall effect produces the type of protection desired in each case. The different types of protection can now be chosen, namely a) increase in the strength of the container, b) protection against mechanical damage and increased container strength, c) increased container strength, protection against mechanical damage and protection against chemical exposure, d)

explosion and leak protection of primary and increased nature with or without a combination of the type of protection according to a) to c).

The chosen laminate layers, respectively laminate layers proposed here *11a* to *11i* are designed to be intrinsically safe and environmentally friendly, that is, they are non-flammable, resistant against aggressive substances, ultraviolet-resistant and ozone-resistant, anti-static, etc. They can be applied to the container walls without any problems because of their - at least initial - flexibility and can also be applied in the refitting process. The symbols of the proposed materials and layers, respectively, that may be used in combination with one another are shown in Fig. 2.

A laminating binder layer to be glued to the respective tank structure, and respectively an adhesion mediating layer for painting is designated as *11a*. In this case it is a nitrile rubber or epoxy resin layer.

A fabric layer of aliphatic polyamide (nylon) that is used, for example as a carrier material for the binder layer *11a*, is designated as *11b*, and produces a fuel-resistant sealing barrier. In combination with subsequent swelling layers it protects them against unintentional activation, for example in the case of loading losses during dome loading.

A so-called tire cord fabric layer is designated with *11c*. The tire cord fabric leads to an increase in the strength of the container structure and has a high elastic action in the two-layer /3

cross-band. This leads to a good protective layer against shooting, since automatic sealing of an up to 30 caliber bullet channel is produced in the original layer.

A solid polyaramide fabric layer that assures a very good protection of the relatively soft laminate layers against mechanical damage and has high shock, breaking, and tearing strength is designated as *11d*.

An elastic polyaramide stretch fabric layer, which is initially highly elastic because of its special type of weaving in the laminate composite and leads to good pressure and shock absorption, is designated as *11e*. At the end of the stretching phase this fabric layer is characterized by a high breaking strength.

A polyaramide cord laminate layer is designated as *11f*, the polyaramide core being produced from combed individual fibers. This layer gives additional strength to the container structure and is characterized by good elastic action in the two layer cross band, which assures automatic sealing of the bullet channel resulting from being shot by munition of up to 50 caliber.

The polyaramide fabric layer *11g* coated with polytetrafluoroethylene is provided for the special protection of the soft laminate layers. It ensures a high shock, breaking, tearing, and abrasion resistance, and also has good chemical attack resistant against acids and solvents and is characterized by a temperature resistance in the great range of -150°C up to +260°C.

Furthermore, so-called swelling layers *11h*, that preferably consist of natural rubber, are provided for self-sealing and leak protection. These so-called active layers swell upon contact with the transported fuel and this automatically seals the leakage site. The emergence of the transport fluid is prevented by combining such swelling layers with a tire cord layer *11c* or polyaramide cord layer *11f*, respectively polyaramide stretch fabric layer *11e*, and also ensures primary explosion protection.

The so-called fluid barrier layer, which is made of an aliphatic polyamide fabric (nylon), is designated as *11i*. Such a barrier layer represents gas diffusion and fuel penetration protection. It prevents the self-activation of the swelling layer *11h* in the case of improper handling of the transported material and limits the swelling capacity in the case of being shot and thus protects against destruction of an extensive area.

Figs. 3 to 14 show different specific designs for the combinations of the layers or laminates described above. Basically - as already mentioned - the combinations of the individual coats, or layers, are chosen corresponding to the material-specific properties.

Thus, Figs. 3 to 6 show versions that offer protection against mechanical damage and chemical exposure. In particular, the version according to Fig. 3 offers additional protection against mechanical damage, the version according to Fig. 4 offers increased protection against mechanical damage, the version according to Fig. 5 offers additional protection against mechanical damage and mechanical effects

from outside and the version according to Fig. 6 offers increased protection against mechanical damage and chemical exposure from outside.

Figs. 7 to 10 show sketches of four versions that offer protection not only against mechanical damage and being shot, but also against explosion and leakage. The version according to Fig. 7 offers a primary explosion and leakage protection in the case of being shot with a bullet of up to 30 caliber and minor mechanical damage, while the version according to Fig. 8 offers increase protection against mechanical damage as well as additional explosion and leakage protection in the case of being shot with a bullet of up to 30 caliber and average mechanical damage. The version according to Fig. 9 offers primary explosion and leakage protection in the case of being shot with a bullet of up to 50 caliber and greater mechanical damage. As compared with this, the version according to Fig. 10 gives increased protection against mechanical damage and primary explosion and leakage protection in the case of being shot with a bullet of up to 50 caliber and average mechanical damage.

Finally, Figs. 11 to 14 show versions that offer protection both against mechanical damage, large-caliber bullets, and chemical exposure, as well as against explosion and leakage. In particular, the version according to Fig. 11 is characterized by an elevated protection against mechanical damage and chemical exposure as well as primary explosion and leakage protection in the case of being shot with a bullet of up to 30 caliber and average mechanical damage. The

variation according to Fig. 12, in contrast, gives additional protection against mechanical damage and chemical exposure as well as primary explosion and leakage protection in the case of being shot with a bullet of up to 30 caliber and minor mechanical damage. In the case of the version according to Fig. 13, elevated protection against mechanical damage and chemical exposure from outside and, in addition to that, primary explosion protection and leakage protection in the case of being shot with a bullet of up to 50 caliber and average mechanical damage. The version according to Fig. 14 offers the highest protection against mechanical damage and chemical exposure from outside and, moreover, primary explosion protection and leak protection in the case of being shot with a bullet of up to 50 caliber and average mechanical damage.

Further explanations ought to be superfluous at this point because of the self-explanatory figures. However, it should be emphasized that possibilities other than the ones shown here also are possible, for example if the requirements are: additional protection against mechanical damage, primary explosion and leak protection in the case of being shot with up to 30 caliber bullets and minor mechanical damage. A combination of the following layers - beginning from the outer tank wall - is to be provided here: layer *11a* + *11c* + *11a* + *11i* + *11h* + *11c* + *11h* + *11c* + *11a* + *11d* + *11a*. With respect to protection and mode of operation such a combination lies approximately between the versions according to Figs. 10 and 11.

The inner wall of the tank can also be provided with a polyurethane foam layer 12 as additional explosion protection and as so-called splash protection, or such a foam can float in the interior of the tank on the liquid to be transported.

Fig. 1

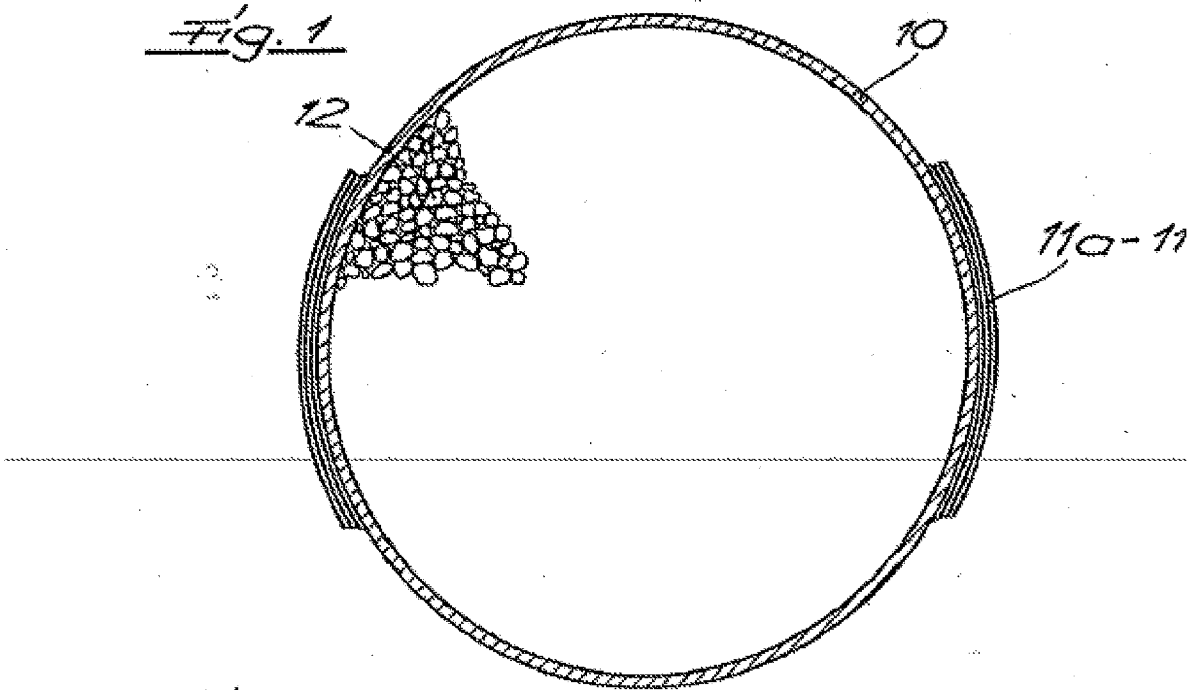
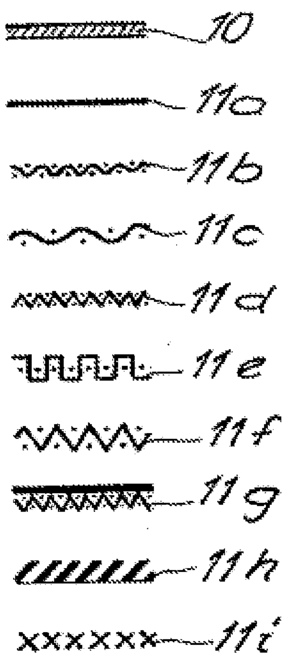


Fig. 2



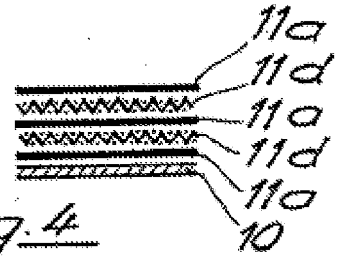


Fig. 4

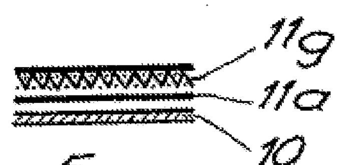


Fig. 5

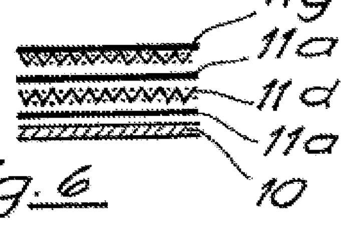


Fig. 6

Fig. 3

Fig. 7

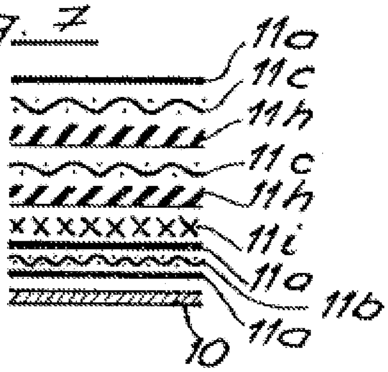


Fig. 8

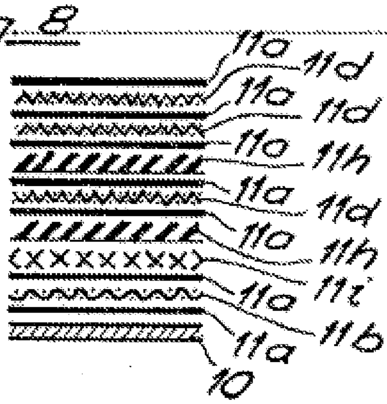


Fig. 9

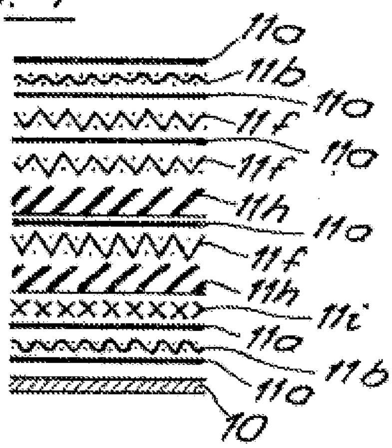


Fig. 10

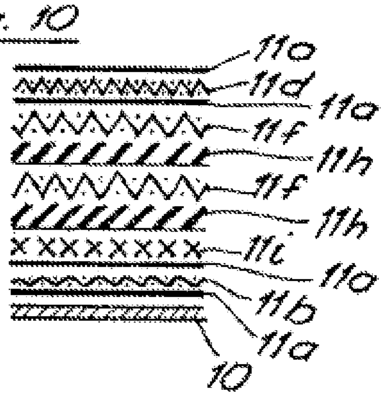


Fig. 11

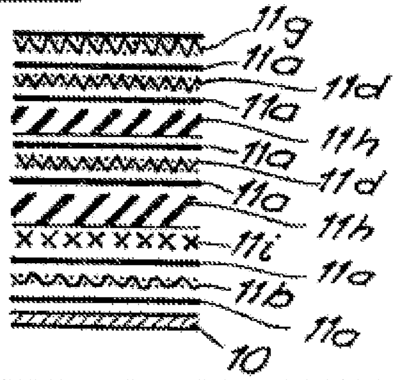


Fig. 12

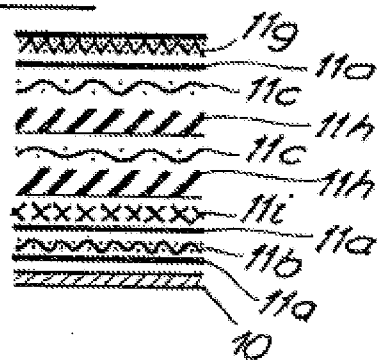


Fig. 13

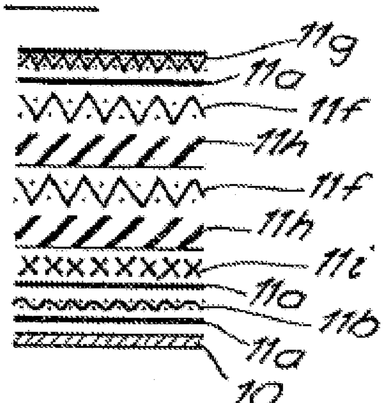


Fig. 14